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ABSTRACT

This study was designed to explore an expert teacher's model of thinking and teaching as it occurred within the social and cultural context of the classroom. The model was then compared with instructional systems design (ISD) to identify similarities and differences between them. To accomplish these goals, the study focused on the process and relationships among four aspects of teacher thinking: (1) the teacher's experiential world and frame of reference; (2) the teacher's knowledge and beliefs; (3) the teacher's planning and interactive teaching; and (4) the teacher's reflective thinking. An ethnographic, naturalistic approach combining different methodological techniques was employed. Data analysis suggested an interactive relationship between teacher's thinking and teaching, and showed that reflection was an integral component of the experienced and competent teacher's thought process. Comparisons between the teacher's model of thinking and teaching with ISD models revealed fundamental differences between them. Separation of instructional planning from implementation and evaluation, the linear or procedural model of teaching and planning, and the concept of reflection or evaluation of effectiveness of instruction after implementation were found to be major sources of differences between the ISD models and the teacher's model. (Contains approximately 40 references.) (LL)

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AN EXPERIENCED TEACHER'S MODEL OF THINKING AND TEACHING: AN ETHNOGRAPHIC STUDY ON TEACHER COGNITION

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Abstract

This study was designed to explore an expert teacher's model of thinking and teaching as it occurred within the social and cultural context of the classroom. The expert teacher's model of thinking and teaching was then compared with instructional systems design to identify the similarities and differences between them. To accomplish these goals, the study focused on the process and relationships among four aspects of teacher thinking: (1) the teacher's experiential world and frame of reference; (2) the teacher's knowledge and beliefs; (3) her planning and interactive teaching, and (4) her reflective thinking.

The study employed a naturalistic approach which combined different methodological techniques. The data were analyzed in the constant comparative style, which allowed categories to emerge from the data. The generated model of the teacher's thinking and teaching was then compared to instructional systems design (ISD) models and principles.

The findings of the study suggested that there was an interactive relationship among the teacher's different components of thinking and teaching. While the teacher's preplanning seemed to be a good indicator of what was going to happen in the classroom, the planning occurred during interactive and reflective phases of thinking and teaching. The data also showed that reflection was an integral component of the experienced and competent teacher's thought process and occurred before, during, and after teaching.

Finally, the results of comparisons between the teacher's model of thinking and teaching with ISD models suggested that there were fundamental differences between these two models. The separation of instructional planning from implementation and evaluation, the linear or procedural model of teaching and planning, and the concept of reflection or evaluation of effectiveness of instruction after implementation were found to be major sources of differences between the ISD models and the teacher's model.

Introduction

Instructional Systems Design (ISD) is a systematic model for determination of both teaching methods and course content. Educators familiar with the concept believe that ISD theory and models have great potential to help teachers teach effectively. They believe that ISD models provide the method for thinking about teaching that is called reflective by advocates of practice (Shrock, & Byrd, 1987). They suggest that efforts should be made to help pre-service and in-service teachers learn and use instructional design approaches and techniques.

However, despite educators' concerns about the quality of instruction and the promises made by instructional designers, the available information on teachers' use of instructional design practices is not encouraging. A number of possible explanations have been proposed by instructional technologists (e.g, complexity of school systems, lack of support for teachers when learning ISD, impracticality of the model for the practitioner). Surprisingly, very little of the knowledge emerging from recent research on teachers' thinking has been used in the field of instructional systems design to understand the problem. The study presented herein attempted to address the issue through linking teachers' practice with instructional design procedures. It explored the possibility that instructional design models could benefit from observing teaching practices in a naturalistic setting.

The purpose of this study was to explore an expert teacher's model of thinking and teaching as it occurred within the social and cultural context of the classroom. It also sought to compare the expert teacher's model of thinking and teaching with those of instructional systems design to identify the similarities and differences between them. To accomplish these goals, the study focused on the process and relationships among four aspects of teacher thinking: (1) the teacher's experiential world and frame of reference; (2) the teacher's knowledge and beliefs; (3) her planning and interactive teaching, and (4) her reflective thinking.

Background: From Teachers as Decision Makers to Teachers as Sense Makers.

Much of the early research on teachers' thinking and decision making was based on an analogy between educational and medical diagnoses (e.g., Barrows & Bennett, 1972; Elstein, Shulman, & Sprafka, 1978). It was believed that the teachers' primary task is to diagnose children's difficulties and progress and, on the basis of these diagnoses, to prescribe effective and appropriate tasks for them. This image of teachers was influenced by theories in cognitive psychology, which in turn were influenced by a communication information-processing model. In 1975, these influences led to research on teachers' thinking that assumed parallel cognitive processes between teachers and physicians (e.g., Fogarty, Wang, & Creek, 1982; Marland, 1977; Morine & Vallance, 1975). These studies focused on teachers' cognitive processes, examining in detail both the structure and content of their thoughts.

Other researchers have sought to demonstrate a close parallel between teachers' thought processes and specific models of thinking, especially the decision-making model (Clark & Peterson, 1986; Shavelson & Stren, 1981). Early models of decision-making process among teachers implied a linear course of action with alternative branches, very similar to the models of diagnostic problem solving in medicine (see Kagan, 1988).

In the past ten years, researchers in the field of teachers' cognition have grown increasingly sensitive to the importance of classroom ecology identifying teachers' problem-solving strategies (Kagan, 1988) . Once researchers began to look closely, it became clear that the classroom environment is complex in terms of multiple activities and continual, unpredictable change. The volume and variety of knowledge and the rapid pace at which teachers must access this knowledge suggests a highly specialized form of clinical problem solving.

Hence in recent years, the image of the teacher as decision maker has been replaced with an image in which "sense-making" is the central cognitive activity of teachers. In this view, teachers not only make decisions but engage in activities, *including decision making*, in order to meet classroom goals (Clark, 1986). The teacher, as sense maker, interprets

classroom events and reacts to them based on his/her personal meaning, past experiences, practical rules and principles, and images. This non-rationale and immediate interpretation of the moments in the classroom and reactions to them are also referred to as reflection-in-action (Schon, 1983). Thus, the metaphor of teacher as physician is giving way to the image of teacher as sense-maker, the image that Schon (1983) called reflective professional.

Within the reflective practitioner metaphor, teachers possess a body of specialized knowledge acquired through training and experience, upon which they rely in their daily work to make meaning. Teachers as professionals must address complex and ambiguous problems, must use their expertise to analyze and interpret these problems, make judgments and decisions, and formulate a course of action intended to benefit their clients. This view of the teacher complements the role definition that emphasizes the technical skills of effective teachers[1]

The Idea of Professional Knowledge: Differing Perspectives

Researchers have conceptualized teachers' knowledge in various ways. Shulman (1986a) defined three types of content knowledge: subject matter knowledge, pedagogical knowledge, and curricular knowledge. Clark and Peterson (1986) discussed two types of theories and beliefs held by teachers: teachers' theories and beliefs about students, and teachers' implicit theories[2] of teaching and learning. Schon (1983) used the term "knowledge-in-action" to describe the knowledge that is embedded in the skilled action of the professional. Other approaches defining aspects of teacher knowledge have included terms such as "craft knowledge" (Brown & McIntyre, 1986), practical theories (Sanders & McCutcheon, 1986), and personal knowledge (Connelly & Clandinin, 1984).

Research on teacher planning and interactive thinking also encompasses work on implicit theories. From a social-psychological standpoint, to understand teacher planning is to

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[1] Technical skills are based on systematic knowledge that is specialized, scientific, and standardized (Clark & Peterson, 1986).

[2] The term implicit theory refers to teachers' systems of thoughts that are based on rules of thumb, generalizations drawn from personal experience, beliefs, values, biases, and prejudices (Clark, 1988). The implicit theories are not clearly expressed by teachers, but they are inferred and reconstructed by researchers on teacher thinking.

understand how teachers transform and interpret knowledge, formulate intentions, and act upon that knowledge and those intentions. From Instructional systems design perspective, planning is systematics design of instruction which is based on detailed analysis of data and information that are gathered and documented by the teacher (Dick & Reiser, 1989). Research in this area reveals a great deal about which features of subject matter; students; and physical, administrative, and political environments actually influence classroom instruction (Clark, 1988). It also highlights differences between teachers' planning models and instructional systems design models of planning (Driscoll, Klein & Sherman, in press; Reiser & Mory, 1991), the latter being linear, rational and objective-based.

The Influence of Context: Focus on Classroom Social Action

The teachers' implicit theory has been supported by findings in the cognitive psychological framework of expertise (Berliner, 1987). Hofer (1986) discussed the schema concept, which assumes that the actions of teachers are structured by means of schemata (networks of knowledge for understanding practice). The basic idea of the schema construct are that knowledge of a situation enables one to perceive similarities between situations and that knowledge can differ in detail. Thus, attention to teacher thinking has revealed the need for more extensive investigation of the various domains of teacher knowledge and of the relationships among teacher knowledge (practical theories), interactive thinking, and classroom action. Parker (1987) has issued a clear warning about the problem of an over-psychological view of teaching and the danger of studying teacher thinking in isolation from its social and professional context. Shulman (1986b) has also been critical of the limited range of teaching activities through which teacher cognition has been investigated. In his view, the choice of these teaching activities has been tied too closely to a behavioristic view of teaching with too little acknowledgment of the validity of the teacher's inside perspective. The emerging image of the teacher as a constructivist who continually builds, elaborates on, and tests his/her personal theory of the world indicates that most cognitive research on teaching has ignored teachers' cognitive processes and methods of processing information interactively. From this

social cognitive perspective, as teachers construct knowledge they will be influenced by the group of individuals with whom they interact (Vygotsky, 1986). Consequently, the relationships among teachers' practical theories of teaching, interactive thinking, and classroom action are guiding present studies of teachers' thinking. In addition, by taking on the role of research informants teachers have become full partners in current ethnographic studies on teachers' thinking process.

Theoretical Framework of the Study

Although research on teachers' thinking does not provide us with a comprehensive theoretical framework for thinking about teaching, a number of assumptions can be derived from previous research and theory in this field. These assumptions, based on a variety of perspectives, provide a holistic picture that makes it possible to make sense of teachers' performance in the context of the classroom. The scheme proposed here (see Figure 1) provides a holistic picture of a teacher's thinking and represents the multiple perspectives that make up the frame of reference in this study. It was derived from previous research and theory

----------Insert Figure 1 about here---------

in the field of teacher cognition and encompasses a multiple view of teaching combining cognitive and social psychology, socio-linguistics, and philosophical perspectives. It explains the major factors of the study and assumed relationships among them and describes the basic epistemological assumptions that underlie the thinking behind this study.

Three basic characteristics define the proposed scheme. First, it is assumed that teaching is a complex, highly contextualized profession, involving a complex form of social interaction that varies depending on context. Therefore, what teachers do can never be comprehended solely in terms of teaching and learning academic subject matter. The formal curriculum of academic knowledge and skills has a counterpart "hidden curriculum" of values and behavior which is embedded in the social and cultural systems of the school and classroom.

Second, there is no linear relationship among the components of the model. Teaching is assumed to be a cyclical, or spiralling process. There is no specific starting point in each cycle.

Third, teaching is a dynamic, on-going, social and dialectical process which is intended to change. Change in the outer layers (teachers' knowledge, beliefs, and values) is basically caused by the center of the cycle (teachers' action), although the factors coming from one's interpretation of the context can also cause changes in the outer layers. The concept of the teacher's culture as a creative, historical system of symbols and meaning is central to this change. The concept of culture is not limited only to verbal expression. Both verbal and nonverbal communication are culturally patterned even though the teacher may not be aware of it. The meaning the teacher gives to his/her experiences (actions) differs from culture to culture. In other words, the way a teacher of a particular culture (e.g., gender, ethnicity, class) categorizes and interprets his/her actions differ from the way another teacher from another culture would do so. A teacher's past experience influences the meaning he/she attaches to present experience, which in turn affects future experience. An example of this phenomenon occurs when highly reflective teaching results in essential changes in the teacher's knowledge and theories of actions.

Figure 1 also shows the basic elements of teaching and teachers' cognition. According to this framework, in order to explain teachers' behavior, it is necessary to look at the classroom as a social and cultural system characterized by reciprocity among participants and between the participants and the physical setting. The basic elements of teaching are teachers' knowledge, beliefs, and perceptions of their craft, which incorporate various students' reactions and perspectives. Skill in teaching rests on teachers' knowledge which can be divided into knowledge of curriculum, pedagogical knowledge, and knowledge about learners (Shulman, 1986a). Teachers' knowledge and beliefs move in a spiral toward more concrete levels of teaching which are prediction, action, and reflection.

There is a direct relationship between teachers' knowledge and beliefs, and the way they interpret their practice, although much of the knowledge that teachers hold and act on is tacit. The beliefs, values, and norms that teachers come to most heavily rely on and frequently use to guide their practice are those consistent with predictions that have "worked" in the complex and demanding classroom arena. While teachers' preactive plans (predictions) provide frameworks for what is possible or likely to occur in classrooms in practice, these frameworks do not function as rigid scripts for teacher activity. Instead, in the interactive process of teaching in which cognition is translated into action, teachers engage in moment-to-moment decision making and problem solving based on their perceptions, practical knowledge, and judgments about the events. Teachers' metacognitive, purpose-driven behavior and/or reflection on the effect of an action helps them to modify their previous pedagogical concepts or to build a new pedagogical principle which, in turn, impacts their future thinking, planning, and action.

Methodology

The exploratory nature of the study, its theoretical framework, and the epistemological assumptions required a method that provided access to different aspects of teaching and teacher cognition in its social and cultural context. Hence a multi-method approach within the tradition of ethnographic or naturalistic research was considered to be appropriate. The broad view of interpretive research allowed the use of triangulation of different methodological techniques. It also made it possible for the researcher to use an approach which answers the study's questions within its multiperspective framework.

Along with most traditions in ethnographic research, this study assumed that culture is central to understanding teacher cognition. It also assumed that three aspects of human culture are central for understanding what goes on in the life of the teacher and his/her teaching processes. One aspect is related to the cognitive organization of the cultural knowledge of humans, which assumes that each bounded group or individual has a unique system of perceiving and organizing the world about them. This means that cultural standards in a

particular context are interpreted by individuals in light of their personal goals, their perceptions of the consequences of various actions, and the meaning they have given to their earlier phases of their lives. In addition, the existence of symbols, including language, enables individuals to construct meaning for objects and provides a foundation for their actions and behaviors as well as their ideas and values.

Another aspect of human culture involves the knowledge shared by particular bounded groups of individuals. It assumes that, through interaction, the individual constructs meaning. It also assumes that both verbal and nonverbal interpersonal interactions (signs and symbols) are culturally patterned (Philips, 1983), and that persons communicating within these patterns usually are not aware of this channeling (Erickson & Mohatt, 1982). Thus, wherever symbol systems are guides to action, they operate within a social context. This gives a symbol or sign its specific meaning, since a symbol or a sign can have one meaning in one social context and another in a different context. Social context, therefore, is a crucial element in comprehending what symbols signify (Applebaum, 1987).

The third aspect of cultural knowledge is formed by environment. As Steward (1936, cited in Hardesty, 1987) explained, environment and culture are not separate spheres; they are interdependent. In this view, neither environment nor culture is "given" but each is defined in terms of the other, and environment plays an active, not just a limiting or selective, role in human affairs (Hardesty, 1987, p. 270). Therefore, the influence of ecology on the culture of individuals should also be taken into consideration in understanding human behavior.

The above assumptions, which incorporate several approaches in the interpretive research paradigm - namely, cognitive anthropology, symbolic interactionism, and ecological anthropology - support a multi-method approach. As a result, the present study utilized basic ethnographic techniques and procedures (participant observation, informal interviews, and collecting and analyzing documents) which were triangulated with microanalyses of actions and cognitive behavior, detailed probing of one teacher's life history, her knowledge and beliefs, and stimulated recall techniques.

Establishing Rigors of the Study

Several strategies were used to establish the integrity of this interpretive research: (a) respondent validation; (b) triangulation; (c) persistent observation and prolonged engagement, (d) thick description of the context, and (e) inter-coding reliability.

Respondent Validation: As part of the on-going data analysis following each interview, the tape or transcript was studied, preliminary interpretations were made, and questions were formulated to guide the next interview. Copies of the transcript were given to the participant and then preliminary interpretations were discussed with her prior to the next interview to obtain feedback on the researcher's judgment and interpretations. The same strategy was used for the observations. Upon completing the data collection and formal analysis, once again the accumulated interpretations and terminologies used to label components of the participant's thought process and the understanding that the researcher had constructed about the teacher's thinking and teaching processes were given to her so that she could explain and correct or comment on any accounts that were given.

Triangulation: Triangulation is based on the notion that every form of data is potentially biased and that various forms of data collection either eliminate or highlight these biases by convergence. As described earlier, in this study, multiple methods (e.g,, ethnographic observations and interviews, stimulated recall, microanalysis of actions) and several data sources (e.g., interview, observation, documents) were used to investigate the same phenomenon. For example, the teacher's thought process during interactive teaching was investigated using interviews after observation, observations of actions, reviewing video tapes of actions, stimulated recall interviews, and teacher's notes. Triangulation of the findings from these multiple sources of data and methods provided the researcher with alternative propositions containing both discernible patterns and inconsistencies or ambiguities.

Persistent observation and prolonged engagement: A seven-month period of exposure to data provided opportunities for the researcher to cross check her observations over time and to reconcile inconsistencies. All original materials of the study without analysis were also

stored for later use by other investigators to test the researcher's interpretations, inferences, and conclusions.

Thick Description of the Context: The theoretical basis for choosing the participant and a detailed description of the context are discussed in this study. This information is presented in a way that allows other researchers to make decisions related to applicability of the findings of this study to another sample and context. Throughout this investigation, the prolonged data collection process, data analysis, participant's checks, and theory development were carefully documented in order to present a rich and thick description for the findings of the study.

Inter-coding Reliability. The study also utilized the strategy of checking the reliability of the coding procedures employed in the study to further establish dependability. To provide a further check on the coding procedures, two colleagues (both familiar with the field of the study) were asked to code a sample of interviews and observations reading the researcher's conceptual framework and methodology of the study and using her procedures for coding and categorizing. One long taped interview and an hour observation were given to two colleagues to recode at least ten minute sections of the transcripts. The reliability of coding procedures, then, was estimated using the following criteria: (a) the same segment of the data was considered to represent a point; (b) for each point, the same semantic word or phrase or sentence was used; and (c) the codes used by different coders had the same meaning as the codes used by the researcher. The reliability was then found by dividing the number of agreements by the total number of agreement and disagreements. The resulting inter-coder reliability was .89.

Selection of Participant

Since the study's purpose was to explore an expert and competent teacher's model of thinking and teaching, an experienced master teacher was sought. The criteria which were used to define an "experienced master teacher" were as follows: (1) possession of an undergraduate degree in the subject matter and graduate degree in education or the subject matter; (2) no record of serious management or discipline problems in the classroom; (3) at

least seven years' classroom experience, preferably three years or more in the context he/she is teaching now; (4) a good reputation among colleagues and students; (5) adequate knowledge about curriculum and organization; (6) excellent regard from his/her principal; and (7) evaluation showing competency as a teacher through classroom observations.

The teacher, Sarah, (a pseudonym) who agreed to participate fulfilled these requirements. She holds the degree qualifications (undergraduate degree in elementary education with a concentration in science, a master's degree in administration and supervision, and teacher certification in the areas of elementary education, administration and supervision), has nineteen years of classroom experience, most of which have been in the school which currently employs her, has been recognized as excellent by her peers and the principal of the school, has had no serious management or discipline problems in her classroom, has been nominated as Teacher of the Year, and has participated in several science research projects during her teaching career. She has also been the head of the science department for several years, has conducted several workshops for science teachers, and has extensive knowledge about curriculum and organization.

The School

The study took place in one of seven public middle schools in a city in the southeast United States. The school is located in a zone that draws from affluent neighborhoods as well as racially and ethnically mixed working class neighborhood of apartments and small houses. A newly constructed public housing project has also relocated a good number of low income families to the neighborhood.

At the time of the study, student enrollment for grades six through eight was 985. About 65.5 percent of the students were white, 30 percent were black, 1.2 percent were Hispanic, and 3.4 percent were Asian, a diversity of population that reflects the district's socioeconomic and racial make-up. According to the annual school report, about 23 percent of the students were eligible for free or reduced lunch due to the low income of their families.

Students' classification into different ability groups also represented a wide range of academic abilities, ranging from gifted, through advanced, average, and learning disabled. Achievement scores at the school are generally ranked as average to slightly above average by the school district.

The overall school culture can be characterized by efforts to empower teachers and implement their innovative ideas, to reinforce teachers' professional development, to encourage team work in order to increase students' exposure to new technology and to continue their good performance, and to facilitate positive interactions among administrators, faculty, students, and parents. Teachers interact closely with one another on both professional and personal levels. Teachers of the same grade level work together planning general rules and discipline for their classrooms. Science teachers, along teachers in other disciplines, also cooperate to share their ideas regarding the use of technology as a tool and in planning classroom activities and projects. The administration and faculty interact closely. The relationship between teachers and the principal was very friendly and Teachers appeared to be comfortable with the principal and confident in his leadership abilities.

The science curriculum is mandated by the school district. In general, its content emphasizes basic skills and basic concepts. It provides science teachers with a set of general objectives and textbooks from which their instruction is derived. The content of the textbooks, which the district adopted two years ago, closely reflects the district's requirements for the science curriculum.

Research Strategy

Data Collection

The study examined four aspects of teacher cognition during data collection: (1) the teacher's experiential world and her frame of reference; (2) her knowledge, theories, and beliefs; (3) her preactive and interactive teaching; and (4) her postactive or reflective thinking. Therefore, four primary sources of data were used: open-ended ethnographic interviews with the teacher; observations of her class with pre- and-post interviews; the teacher's notes,

classroom materials, textbook, tests, and other records related to students' performance; and stimulated recall interviews.

Data was collected over a seven-month period, beginning at the end of the school term in May 1992 and continuing through December 1992. Between May and August, more than six long interviews (each about one hour and one-half) were conducted with Sarah. From August 14 to August 24, 1992, just prior to the school year's opening, the researcher attended teachers' and the school pre-planning sessions. Sarah's classroom was observed every day for the first three months of the year. During this period, interviews were also conducted before and after each classroom observation. During the last month, the researcher showed the videotapes of classroom actions to the teacher weekly and discussed classroom actions and interpretations with her.

Interviews: This initial phase of the study focused on the teacher's life history, including her knowledge, theories, beliefs, values, and perceptions of teaching. It was conducted during the summer and prior to classroom observations. The first interviews served as a data base for further questioning and began with general questions. These general questions progressed gradually in further interviews to more specific and narrow questions. The basic strategy during interviews was to allow Sarah to tell her own story in her own terms. As she talked, the researcher asked different probing questions in order to understand Sarah's interpretations. This line of questioning, based on what Sarah said, expressed the researcher's interest and reflected back her statements once she began giving an account of some events. All interviews were audio-taped and transcribed for further analysis.

Observation and Interviews: This phase of the study was a combination of observations and informal interviews focusing on annual planning. During this period of time, the researcher attended teachers' large-group and small-group meetings for pre-planning at the school level. Sarah's preplanning activities were observed and some informal discussions was also initiated with her in this regard. The discussion theme depended completely on the type of activities she and the other teachers in the science department were involved in. The researcher

collected notes at all group meetings including a general plan for discipline and grading. Sarah's notes and written plans were also gathered during this period.

Classroom Observations and Interviews: After the beginning of the school year, Sarah's classroom was observed every day for three consecutive months. The researcher participated in Sarah's classroom from 8;50 am to 11:30 am, covering three periods including the homeroom class. The selected classes, which were classified as advanced by the school, were in physical science. The first two weeks of observations were audio-taped to allow enough time for obtaining parental permission for videotaping the classroom and also to enable the researcher to become familiar with the context and for students to get used to the presence of the researcher in the classroom. This time also helped the researcher to identify the best place for the video camera. After the first two weeks, Sarah's performance in the first period was video-taped, while the second period was audio taped. Transcriptions of audio and video tapes were then combined with the field notes, which concentrated primarily on elements missed by the tape recorder or video tape (e.g., students' reactions to Sarah's questions or explanations, information on the chalk board, and students' body language and expressions, movements around the room, and softly spoken dialogue).

During the period of observation, interviews were also conducted before and after each classroom observation and all Sarah's classroom materials, including the textbook, tests, and other records related to students' performance were collected.

Stimulated Recall Interviews: During the last month, the researcher met weekly with the teacher to discuss her interactive teaching and her reflection on her action during and after viewing the videotapes of the classroom actions. Since there was no practical way of looking at all videotapes with Sarah[3], four sample videotapes of the classroom were chosen and Sarah

[3] To have Sarah's reactions to different samples of classroom interactions I chose videotapes of four lessons, one from each of four different units (out of ten to twelve videotapes for each unit). I also tried to select different classroom interactions (e.g., hands-on activity, book work activity, direct interaction between the teacher and students, and teacher's demonstrations and presentations).

was asked to review them while the researcher asked her questions[4]. All stimulated recall interviews were audio-taped and transcribed for further analysis.

Data Analysis

Data was analyzed and collected concurrently so that the phase of data collection merged with that of data analysis. The object of analysis was to determine the categories, relationships, and assumptions that form the respondent's view of teaching. The general strategy for this analysis was a constant comparative style (Strauss, 1987), which permitted the categories to emerge from the data. In the initial phase, the analysis was run for each different data source separately, ignoring its relationship to other sources. This first stage treated each utterance in the interview transcripts, actions on videotape, site field notes, and other documents on its own terms to produce concepts that fit the data. It emphasized careful reading of the document to determine what was in the data and what the data "set off" in the self. In this stage, which Strauss (1987) calls "open coding," codes or terms used by the informant were identified and used as keywords for the piece of data, sentences, or incidents. An attempt was made to identify as many codes as possible to ensure full theoretical coverage.

The second stage of analysis took each conceptual code that was generated through intensive analysis around one category and sought to define the relationship between that category and other categories and subcategories. This was done through a close examination of evidence related to each category and its relation to the others. Examination of conceptualized linkage among categories led to the choice of some core categories that became guides to further data collection and data analysis. The core categories were given "best fit" labels (not necessarily in the data but semantically equivalent to the categories). This stage was also continued by searching for categories that related to the core codes and eliminating redundant themes. During this process, extensive analytical comments or memos were written.

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[4] Example questions were: "What were you thinking in this segment?," "Were you thinking of any alternative actions or strategies at that time?," "Have you thought about this event since then?," What was the content of your thinking?."

The third stage of analysis examined the interconnection of categories across different sources of data, resorting them once again and checking for inter-themal consistency and contradiction. The object of this stage of analysis was to determine the patterns and themes that appeared in the several data sources that made up the study and subject them to a final process of analysis. The final products of this stage were theses that brought together the core categories or themes from different sources of data to be discussed as analytic categories.

Another type of analysis undertaken independently throughout the data collection stage was construction of a graphic model of Sarah's teaching and thinking for comparison with instructional design models. For this analysis, the generated categories of the teacher's knowledge, theories and beliefs, and thinking during preactive, interactive, and reflective processes of teaching and interrelationships among these elements were used to reconstruct the proposed theoretical model of the teacher's thinking and teaching. This proposal was then revised through the stimulated recall interviews and confirmatory dialogue with the teacher, who was encouraged to alter and supplement the graph until she fully agreed with its content. This graphic representation, along with the analytic categories and generated theories, was compared with instructional design models and principles for further discussion.

Extensive field notes, interviews transcripts, documents, analytic memos, and schemas were entered into five various data stacks in the data-collection management system of *HyperQual*, a Macintosh-based software program for recording, sorting, and analyzing qualitative data. This program facilitated the coding of chunks of data, which were then sorted several times to identify relevant categories or concepts in the data.

Eighth Grade Science Classroom : Classroom Environment and its Social Organization

Sarah's teaching assignment consisted of five eighth grade science classes (three advanced, one gifted, and one regular). Sarah's advanced classes consisted of 30 to 35 students, and her regular and gifted classes consisted of 21 to 28 students. The majority of students in advanced and gifted groups were white and from middle and upper class families,

> I want everybody to do their five items (measuring length, volume, mass and density of five items) and then collaborate. It is not cheating. You are checking each other. Work together (emphasis on the word "together"). You find the mass, then when somebody else wants to find the mass, put it back to zero, do your computation. . . .

Sarah also changed the school practice regarding requiring science fair projects to something that she believed was more creative.

> I'm not going to demand science fair projects. As a group we may choose to do something and we have to talk about it. We have to do a science fair or something else, so we're going to change the science fair a little bit if we want to do that. If I demand a science fair, it's not going to be a typical science fair. I am going to allow research papers. . . .

However, there were many rules, routines, and norms that were not taught explicitly and directly. They were established through interactions between Sarah and her students and were communicated indirectly to students. Sarah and her students continuously negotiated these rules and regulations in their class discussions and came to agreement about them. Although these negotiations were often implicit in their interactions, the result was a set of behaviors that were guided by these rules and norms and were crucial in establishing the routines and patterns necessary for the smooth functioning of the class. For example, in the following interactions between Sarah and students, she was reminding students to use the proper unit of measurement. Implicit in this interaction were several rules that, although not taught explicitly, students learned to apply appropriately. For this discussion, students had to actively monitor and process Sarah's messages about the task and participation rules, inferring the covert messages sent by her cues, such as tone of voice, changes in pitch, facial expressions, or chains of questioning and responses. An example occurred when Sarah asked questions and did not call names implying that, any student could answer her questions. The students also understood that when Sarah repeated a question followed by a quizzical expression on her face or asked another question, it meant she was not satisfied with the answer, and the respondent should try again. When she repeated the answer with a confirmatory voice, it meant she was satisfied with the response, and they were ready to move to another question.

> Sarah: So, if you are measuring liquid, you are going to use what unit of measurement?

whereas the majority of students in the regular group were black and from middle and lower class families.

Sarah's classroom was located in the southeast of the school on the second floor. The room looked small with four long rows of desks on the right side of the classroom and three short rows at the left side being separated by a narrow passway between the rows. A wide curtain- covered window brought light to the classroom while letting the teacher darken the room if needed. Two small storage closets (one behind the teacher's table) held most laboratory equipment. Two big chalk boards, two bulletin boards, and three cabinets covered all the walls around the room. A book shelf filled with old and new science textbooks, a few dictionaries, and science magazines was below one of the bulletin boards at the back of the room. A lab table with established faucet, refrigerator, gas light, and shower (for emergency situations) separated the teacher's territory from the students and enabled the lab demonstrations to be held in the classroom. A video monitor with videotape, a laser disk player, an overhead projector with data display, a Macintosh microcomputer with a printer, an apple II computer, and a film projector were all placed at different corners of the classroom, reminding one of being in a classroom in the age of the technology.

Sarah's science classroom, like any other social group, was a rule governed community. During the first two weeks of school, Sarah spent a lot of time reviewing, explaining, and rationalizing classroom rules, regulations, and expectations. By instructing students in rules and routines and reinforcing positive expectations and social labels, Sarah helped students acculturate to their small community. Some of the rules and regulations that Sarah set and reinforced directly at the beginning of the school year were those that incorporated the school's rules. Some other rules either were specific to Sarah's classroom or were modification of traditional classroom rules. For example, Sarah tried to modify the well-established traditional classroom rule that views peer helping as cheating. In an attempt to change this rule, she encouraged students to collaborate and to help each other with book and lab assignments, although she expected each student to turn in his/her own individual work.

Student 1: Liter
Sarah: Liter, so, that is your origin. If we are doing liquids, it is liter. What else could we measure?
Student 2: Meter
Sarah: Meter, length of something. How tall you are. How high you can go. We are going to use meter for length. Okay, we are also going to talk about different scales in more detail.
Student 3: Gram
Sarah: For measuring what?
Student 3: No answer
Sarah: For finding how heavy things are. You are going to deal with grams for measuring.

The implicit rules were not always set by Sarah; students also participated in rule setting and when this happened, Sarah conformed to the rule. For example, in classroom interactions, students set the norm that if they did not answer Sarah's question, it meant either they were tired and the lesson was not interesting any more, or they did not understand the question. Therefore, Sarah had to interpret signals coming from students and adjust the lesson accordingly. In the following interaction between Sarah and students, Sarah had to interpret students' reactions to her question and changed her instructional strategy although students did not tell Sarah what she should have expected from them.

Sarah: It rusts very easily. If it is something that is made of iron. It gets an awful rust on it. Anything else you have that you want to check with me?
Students: No answer
Sarah: Good, you probably have no problem with it. You can tell what color it is, you can tell that it is metal, you can tell it is malleable. Easy to use a maldive on it and jewelry on it. The more metal something has on it, the more bendable it is. It doesn't rust, does it?

Thus, as a social group, Sarah and her students gradually built a classroom community in which some of the rules were carried over from the school outside of the classroom, and others were generated within it. Reciprocal obligations and expectations were negotiated and renegotiated during the class by Sarah and students as they mutually constructed the social norms that form the basis for group interaction. Rules and norms within this small social community were both explicitly and tacitly taught and agreed upon by its members.

The Findings

The Teacher's Experiential World

Implicit in Sarah's knowledge and actions were her personal and social experiences. Sarah went into the classroom with personal beliefs about classroom and students and images of herself as a teacher. For the most part, these preconceptions and images were associated

with her biography, her experiences in classrooms, her relationships with other teachers and authority figures, and recollections being a student in a classroom.

In-depth interviews with Sarah and observations of her subsequent actions and reflections revealed that Sarah's experience as a learner and as a teacher influenced her image of herself as a teacher and her students as learners. Sarah's life history provided strong roots for her beliefs about students and their role in the learning process. Her stories about the problems and difficulties that she experienced at school when she was a child give evidence of her strong beliefs about students and their roles.

> I had an extremely bad experience as a child. I imagine today what they would have done, they would operate on my tongue. My tongue isn't long enough so, I could not say words with Rs. So, I spent my first year in the school in the speech class. They pulled me out of my reading or math class to go to the speech teacher. . . . I had a second-grade teacher who was very egocentric. In fact, I will never forget her. She would feed us with chocolate and I was, I guess, a pistol and refused to do something, which back then you just didn't do. She recommended that I be put in the special education classroom. Well, the problem was nobody could understand me. I probably should say some did. I heard from my mother that one of my teachers wrote in my file "on the playground she is a leader and organizer of the other children." But you know, back then they could stick you in special education without any test, and you would be stuck there forever.

During the years of difficulties and problems, Sarah received continuous support from her parents. She believes that her mother was the key to her success because she was the one who stood by her and made her believe that she could be as successful as any of her peers if she just wanted to and set her mind to it. Sarah's father was another positive influence in her education. He stimulated Sarah's interest in science by assisting her with science activities, the area in which she could then impress her teachers and show them her intellectual abilities.

As a result of these experiences, Sarah now holds the view that all students are able to perform well if they put their best effort into learning. She also believes that students who do not do well in school are those who often do not receive family support. She thinks that teachers should not lower their expectations just because students are not performing well. On the contrary, she believes they should set high expectations and try to help students reach those levels.

> You know, I'm real careful. I won't assume things. I always look for my underlying feelings and I also expect the best of my students just like my parents did for me. I think anybody can do anything that he/she wants to. It may take more effort for some people but I think you can do it. I also read a lot

> about how people learn. The idea of left and right brain has been fascinating to me. . . . I like my students to be successful and also like my class. I think if you are unhappy and dislike the class, the way I was in my high school, no matter how intelligent you are, you are not going to do well, or let me put it this way, as well as you could.

Sarah's early experiences as a teacher also affected the way she thinks of herself as a teacher and the way she performs in the classroom. The survival stage of Sarah's professional life made her assess the first years of teaching experience as years of hard work and frustration as well as years of learning and success.

> I started off in the morning with a very sophisticated group of eighth graders. But I also taught sixth and seventh graders that year. I also had lunch duty. So, I started off with a year that was very difficult. I basically had four different preparations as a science teacher. I had two physical sciences, which was a lot of chemistry, one life science, one airspace, and one lunch duty. . . . I think it was very, very difficult. I am thankful that I didn't have children at that time, and my husband had to travel a lot, because I spent hours and hours planning. I also don't know what I would have done without the other teachers. In most cases there was one in each grade level, and it was definitely a team player. They would have done my lesson plans for me if I wanted them to. If I was doing a lab activity, they would help me out with the lab so that my students didn't suffer.

She believes that she could not have survived those years without guiding from the more experienced teachers in the school. She received personal assistance from her colleagues and mastered the group's pedagogical and technical knowledge. Therefore, Sarah's teaching in these years was influenced and was highly affected by collegial relationships and interactions.

In her present school, Sarah has changed from being a novice teacher to an expert. Sarah felt more confident and comfortable adjusting to the new school and subject matter this time. However, she thinks there were many specific contextual problems that required mental readjustment.

> When I first came into this room it was with little equipment. They (the school and science department) were going through the old ISCS (Intermediate Science Curriculum Study materials), but they had gone through the money several years before that and we didn't have any money to spend on equipment. So, we couldn't give any hands-on science experiences. You know hands-on experience is quite expensive. So, the first few years I taught straight out of the textbook, which was extremely boring for me and the kids. I was in my territory and they were in theirs. I had to rely on the textbook a lot more than I wanted to. I also was dealing with biological science rather than physical science that they (the school) had me teach.

Although it has now been more than 14 years since Sarah began teaching science in her present school, she believes that she has to change and adjust to the context every year because, although she is at the same school, neither she nor the students are the same year to year. Thus, Sarah's early experiences as a teacher appear to be the major source of her pedagogical

knowledge, and her professional knowledge and competence continue to evolve from her teaching and learning experiences.

The Teacher's Knowledge, Beliefs, and Theories of Action

During years of teaching and learning, Sarah built a body of practical knowledge from which she drew most of her teaching theory and practice. Sarah's implicit knowledge and theories of actions were basically constructed through experimentation. This practical and implicit knowledge can be described in terms of five categories: knowledge of self as a teacher, knowledge of content and curriculum, knowledge of pedagogy, knowledge of students, and knowledge of context.

Knowledge of Self as a Teacher: Sarah's knowledge of herself and her role as a teacher has three aspects. First, as a teacher, Sarah has a good sense of who she is and who she wants to be. She believes that as a teacher she is not and should not be a mere disseminator of information. On the contrary, she thinks she is and should be a facilitator who helps students find the information. Sarah's self-image helps her push herself to move ahead in areas where she needs to change in order to achieve instructional goals. Second, Sarah sees herself as an individual with unique characteristics and biases. Sarah's knowledge of her limitations also influences her actions and relationships with students. Third, Sarah takes her role as a teacher very seriously and looks upon herself as a professional. She thinks teaching is a complex and intellectually demanding task even under the best circumstances. She also demonstrates her professionalism by setting rules for her relationships with students and judgments she makes about them.

Knowledge of Content : Sarah's view of science as an academic discipline has two dimensions: cognitive and affective. Both dimensions coexist and correlate within her view of the subject of science. Sarah believes that science as a discipline is not limited to memorizing facts and terminology, but involves utilization of knowledge in real life, and her emphasis is that utilization. This epistemological belief is rooted in Sarah's general philosophy of learning.

> What I feel for learning is that they ought to be able to use that information somewhere else, like at home to save them time in doing something else. If they learned English they ought to be able to write a letter for someone. I see that as learning, as being able to use it and apply it to everyday life.

The view of science as a "doing" discipline, therefore, makes Sarah believe that critical thinking and problem solving should be the focus of science, especially physical science. Because Sarah is aware that science progresses every day so that what was a fact yesterday may no longer be a fact tomorrow, she believes that it is an ideal classroom medium through which to emphasize thinking and doing skills.

> Sometimes you like to see them (students) become frustrated because that means they're thinking and trying, and in science there isn't always a right answer. That's what I try to emphasize to them that you may come out with a different answer from your neighbors, but don't think that you're always wrong. You may just have approached the problem in a different way.

The affective dimension of Sarah's view of science is related to her cognitive conception. Sarah believes that students will like physical science when they see that it can make their lives easier. She believes that seeing the application of physical science in real life and using it in daily life makes science exciting and fun for students. Therefore, having fun and enjoying the activities are important elements in Sarah's science instruction.

Consistent with her view of science, Sarah designed lab activities and tests that were primarily performance-based, in which students had to apply their skills and knowledge. Sarah's class discussion questions questions went along with her view of how to teach science. She seldom asked students for definitions of new terms or concepts without wanting them to use the concepts for solving problem-based questions.

> Sarah: . . . . the only thing that I'm going to give you is that some of you may be travelling somewhere this weekend. Even if it is going to be from your home to grocery store. How many miles does it take? Or you may take one day this weekend and write down every time you use measurement, any time that you use something to measure.
> Student 1: What? For example, whatever we want to drink?
> Sarah: Well, how much do you drink?
> Student 1: I usually drink from a cooler.
> Sarah: (addresses the whole class): OK, estimate cooler. What unit of measurement is he going to use?
> Student 2: Quarter
> Sarah: Is quarter in the metric system?
> Student 2: Uhm..... (thinking)
> Sarah: Example, they sell one to two liter drinks now (she takes a milk bottle of drink from her desk and shows it to students). Milk, if you have ever noticed, tells you about gallons and also about liters (she looks at the bottle in her hand and reads the numbers on it). This happens to be half a gallon, but it tells me that it's 1.89 liters. Everything that I have been able to find has both measurements on it. So, if you measure liquid, you are going to use what unit of measure?

Knowledge of Curriculum: Sarah headed the science department for several years. She has served as a science resource teacher for the school district, taught several workshops for science teachers in the area of physical science and integrating computers into the science curriculum. Each of these tasks contributed in a different way to the development of her practical knowledge of the science curriculum.

Sarah's extensive knowledge of teaching and the learning environment helped her identify appropriate content, activities, materials, and teaching strategies and adjust curriculum resources to the context. She also adapted the context to make it compatible with her own beliefs and value system. As Sarah reported the processes that she followed to design her physical science course, it was obvious that she was actively involved in developing curriculum while taking into account the students' interests and abilities, school goals and expectations, community needs and requirements, and physical and social constraints. This indicated that Sarah functioned as a curriculum designer instead of being only an implementer of a predetermined body of knowledge. However, curricular materials, textbooks, activities, and tests also influenced her construction of the curriculum.

> I try to get as many resources as I can. I adapt things, I see things; Mr. Wizard for example, I used to watch him a lot. I just watched him and read him a lot which gave me some ideas on things that I would like to use with kids. . . . I've had my own library; I have a folder of activities, the workshops that I've gone to in summer, and they have given me some good ideas. The books with good lab manuals that I can adapt them. . . . I would make sure that I could use hands-on activities with the kids as much as possible. I would look at what they (officials) have given me and see if I could turn them into doing activities. . . . I schedule the easier and funnier units for the end of the year, when kids are bored, not always on task, and miss the class a lot. So, I work my units around knowing whether they are easy concepts or harder concepts to understand, whether my activities will make the concept easier to understand. Some kids may never miss a class, others may miss a lot, because they're so active in different activities. I don't want to make it difficult for those who have to make it up. Chemistry is the one that if students are out of the school, is harder to make up. So, I need to think about that.

Pedagogical Knowledge: Sarah's pedagogical knowledge incorporated all other aspects of her practical knowledge, including her view of learning and knowledge of teaching. Sarah's "learning theory" is simple and appealing. This belief is reflected in her emphasis on the usefulness of laboratory activities, real world examples, and application exercises in which students have a chance to use their scientific knowledge to solve real life problems.

Sarah's knowledge of the teaching process involves a number of basic beliefs about the act of teaching. One basic belief about teaching that underlies Sarah's actions is the idea that teaching is like acting and teachers should be like actors or actresses. Sarah's metaphor of "acting" for teaching includes the use of both physical and non-verbal expressions to communicate with students.

> I think teachers need to be actresses. Eyes are important, facial expressions are important, being able to control your temper, good or bad is important. Usually I can pretty well come up with good acting, my face turning red, so that they think that you are about to explode.

She uses body language and facial expressions to communicate the classroom rules and her expectations, to express her anger, joy, and satisfaction, and to control discipline problems.

Sarah also had well-developed beliefs about how instruction should be organized. Several practical principles learned from experience are a basic part of Sarah's knowledge of instruction. For example, the importance of clearly communicating what is going to happen in a classroom session and what is expected from students before beginning instruction is one principle. Another is Sarah's belief about providing a variety of activities and materials rather than repeating using the same materials and activities. This notion of the importance of having a variety of activities and materials helps her plan for instruction and prepare for different actions and reactions.

Sarah's instruction was also highly influenced by her student methodology evaluation. Sarah has two ways of evaluating students' performance, one through ongoing monitoring and evaluating of students' performance on the basis of linguistic performance or daily participation during lessons, the other through testing. Sarah's linguistic evaluation is often covert and is done unconsciously. This evaluation often leads to judgments about students' readiness and backgrounds and increases Sarah's knowledge of students and their needs. She explain this implicit view of evaluation in her stimulated recall interview.

> You know, I wasn't sure that they knew how to read the meter stick and there was no way for me to check thirty-five students to see if they can read so this was my way of giving them an introduction and seeing how much they knew. That was my real reason for using the questioning technique. You know, I could go up there and say boom, boom, boom, but I don't get to know them, and it is not enjoyable. I really try to do a lot of this because it gives me a chance to get to know them, I can hear

> their responses and I can see how they think. And I think I do a lot of this at the beginning of the year.

Sarah's classroom testing involved far more than giving students marks for their accomplishments. She viewed the tests as a means of knowing students and adjusting her instruction to their needs. For her, tests and assignments were also sources of information on why students did not do well and a good source for reflecting on her instruction. Sarah viewed tests as a way of communicating to students how they are progressing in terms of classroom goals and expectations. This belief reflects Sarah's views of testing as a barometer of the effectiveness of her instruction as well as the effectiveness of students' learning strategies. Giving test results back to students the day after administering the test demonstrates this underlying belief.

Knowledge of Students: Sarah's view of students is the most developed part of her practical knowledge. Sarah has a deep faith in students' abilities for success. The following comments show some of the Sarah's beliefs about students and their abilities.

> I remember the story that there was a young man in my class that was the worst behaved student that I have ever seen. But I decided that there ought to be some changes. And it was amazing that the young man turned himself around. And I actually enjoyed being around him that year. I think that's important that you set the goal and decide that you are going to let your feelings stay. You are going to change them. Do everything in your power to change them. If you have negative attitude toward students, I think it is impossible. . . . Students change, especially seventh and eighth graders. When there is a break and they come back after two weeks, they are different. They become young men and women. It also depends on the subject. Every chapter or unit that I teach I will see a bright spot and someone all of a sudden will shine. So they are not all the same person all the time throughout the year. . . . Doing well is what I expect for all of them. They do their best when you put them into the pressure of doing their best. I think it is human nature that we would do things that if we were not pressured we normally wouldn't do. But you know I don't want them to feel pressured to change their nature.

Sarah's view of students reflects the view of learning outlined in the previous section. The idea of the active role for students, the notion of being responsible for one's own learning, and the issue of variability in styles of learning are all different features of Sarah's view of students and learning.

Knowledge of Context: Sarah's knowledge of context is evidenced by the way she expresses her beliefs about the context and by the way she organizes her actions and interactions in the classroom and in the school. Sarah is very well aware of the fact that her

actions and interactions are different based on what social and cultural setting or school she is in. In other words, she views her classroom as being nested or embedded within the school. When Sarah talks about previous experiences in different schools, she clearly identifies the contextual differences that influence her teaching and her classroom as a smaller organization within the school.

> You know the problems over there were very little because the discipline was very strong in that school. They were also very supportive; I wasn't threatened by the assistant principal coming into the room. I felt very comfortable. . . . But my first year here was a different story because the administration wasn't that strong. The assistant principal wasn't supportive. They wanted us to paddle and I didn't feel comfortable doing that. The teacher that was supposed to help me wasn't really helpful. . . . In here they check our lesson plans but they don't make us write behavioral objectives. But when I taught at . . . many years ago, we had to turn in our lesson plans for every week with the behavioral objectives and the materials to use.

In Sarah's view, the classroom is composed of teachers, students, physical environment and equipment. In this context Sarah sees herself as a creator of learning environment and the student as a person who learns as a result of that environment. She thinks that students' backgrounds and characteristics change the context of the classroom interactions. She also thinks of classroom facilities and equipment as important factors that can create different learning contexts. Sarah believes that students' responses to her questions and the degree of their conversational cooperation change the learning context of the classroom and demand different actions and interactions from her and the students.

> You see, both groups had ten minutes for practice, but in second period it seemed like they had too much time because they gave me the answers right away so we spent less time discussing. But in first period, it seemed that the time was not enough and even, if you noticed, we ran out of time. So, I knew that I was going to give them ten minutes for practice, but because of that second period had more time practicing.

The Teacher's Pre-Planning, and Interactive Thinking

Several sources of data (e.g., ethnographic interviews, observations, and document analysis) indicate that Sarah engaged in at least three types of planning: course or yearly planning, unit planning, and daily or lesson planning. Sarah's different types of planning were nested in one another and interacted in complex ways.

Sarah's yearly planning had three functions: personal, instructional, and managerial. The personal function of yearly planning for Sarah was to give her a sense of security about

meeting curriculum requirements and reducing uncertainty and anxiety about instructional activities, time schedules, necessary equipment, and materials. The instructional function of the yearly planning was to modify the curriculum, based on Sarah's previous experience and beliefs system, for the classroom situation. Yearly planning also functioned as a rule setting process for Sarah's classroom management. In this regard, yearly planning served as a framework within which the classroom as a social system worked.

The ethnographic and informal pre- and post-observation interviews with Sarah also provided some information about the components and processes of Sarah's planning. According to this segment of the data, at the time of yearly planning, Sarah simultaneously thought about several different factors and considered them for her planning. Figures 2 shows components of Sarah's thinking during planning, and Figure 3 illustrates the elements of Sarah's yearly planning. The highlighted boxes in Figure 3 show the actions that Sarah took during her yearly planning.

---------Insert Figure 2 and 3 about here--------

Sarah's unit plans consisted of weekly plans and took the form of lists and notes in a teacher's plan book that outlined day-by-day activities, assignments, and tests. Day-by-day outlines were later completed with more detailed notes about homework assignments, laboratory activities, textbook exercises, tests, and content outlines, which served as Sarah's written daily plans. Table 1 shows an example of Sarah's daily plan.

---------Insert Table 1 about here--------

In her unit plans, Sarah also anticipated how she would assess students' learning outcomes and what kind of tests she would use to evaluate students' learning. However, as mentioned earlier, she did not develop or adapt the end-of-unit test items until she had a good sense of instructional progress. Sarah also used written quizzes for each unit to gauge students' understanding of the instruction. As a part of classroom activities, the quizzes became embedded assessment of instruction. They served as a learning strategy in that they exposed and corrected flows in students' thinking and as a cognitive strategy in that they helped

students adjust themselves to meet Sarah's expectations. The quizzes also permitted Sarah to adjust her expectations to the students' level of understanding and assess instructional success.

The daily conversation with Sarah before or after classroom observations revealed that all of her written plans were supported by well-developed mental plans. Sarah had detailed images of different classroom activities and the sequence of these activities, instructional strategies, students' probable reactions and responses, the arrangement of the classroom and materials, and possible problems. These images were cued by her sketchy notes and helped Sarah put herself into a complex context with all the detailed information related to the classroom environment that she wanted to remember during her actions. Thus, unit and daily plans influenced both Sarah's and students' actions and interactions in the classroom

Planning, Interactive, and Reflective Teaching

Although Sarah's pre-planning was a good indicator of what was going to happen in the classroom, the social context of the classroom required continuous changes and/or modification of pre-plans during interactive teaching. The relationship between Sarah's pre-plans and what actually happened in the classroom became less predictable when verbal interaction became the dominant teaching method and Sarah chose to let classroom interaction drive the instruction. In such cases, since specific verbal interactions were unpredictable, Sarah changed her plans during interaction by reflection-in-action. For example, in the following episode, when Sarah was confronted with students' questions, she had to first give up some of the control that she had over the conversation and discussion, and, second, she became more interactive and started to change her plan, and to adjust it to the context.

Plan for the day: Large group discussion on states of matter

Classroom discussion
Sarah: These elements, some of them, are made up of only one atom. For example, Helium has only one atom and that makes up the element Helium, whereas. . . . (John makes Sarah stop by raising his hand)
Sarah: Yes, John
John: All elements are made up of just one atom.
Sarah: Well, you read Oxygen . . . . (John interrupts Sarah again)
John: But it says it is a compound in the book.
Sarah (Pauses for a second and then says): Read the book's definition for me.

John (reads the book): "If a sample of matter is composed of one kind of atom, that sample is an element."
Sarah (while repeating the definition for John): . . . one kind of atom. Let me use an example. You see the oxygen, oxygen is never found by itself. It is one atom. Okay, let's look at the book. I may disagree with the book if it says that's a compound, because it is not a compound; it is an element. What is the definition of the book for compound?
A volunteer student reads: A compound composed of two or more types of atoms.
Sarah: See, two or more types of atoms. A type of atom is an element. For example, these two elements of oxygen (points to the slide on the TV monitor) both look alike. They both have eight protons, eight neutrons and eight electrons. . . .
John (still not convinced): But oxygen doesn't have one atom; it has two atoms.
Sarah: But, oxygen is an element, consisting of two atoms. . . .

Sarah's major sources of information during interactive decision making were students' interests, understanding, and involvement in the task.

The stimulated recall interview analysis of the teachers' actions as well as informal interviews conducted after classroom observations gave evidence that Sarah engaged in two forms of reflection: reflection-in-action and reflection-on-action. While reflection in action happened in the midst of Sarah's actions, reflection on action occurred after the instruction. Both forms of reflection produced some changes in Sarah's instructions, one in her current actions and the other in her future actions.

Sarah's reflection-in-action brought about changes that were responsive to the situation at hand. During interactive teaching, certain cues from the environment activated an immediate interpretation and response. Sarah's immediate interpretation of the environment led her to new discoveries and meanings that were tested for future use. Making sense of the new situation and determination of its features were based on the sources of the information that Sarah had available to her, her interpretation of that information, and her prior knowledge and experience. Table 2 summaries examples of Sarah's processes of reflection-in-action and their effects on her future practice.

---------Insert Table 2 about here--------

Reflection-in-action also made Sarah's instruction interactive and responsive to the context and influenced her to adjust her instruction to students' needs and interests.

In sum, Sarah's pre-planning and interactive teaching were influenced by her philosophy of "learning is doing," the role she assigned herself as a teacher, the students'

roles, and her knowledge of content, context, curriculum, pedagogy, and students. Sarah's planning was not limited to her preactive thinking. Planning also occurred during the interactive and reflective phases of the teacher's thinking. Triangulation of different aspects of Sarah's thinking processes suggested interactive relationships among her beliefs, values, and perceptions; knowledge and theories of actions; pre-planning and interactive teaching; and reflective practices. The evidence also suggested that reflection was an integral component of the teacher's thought process and that it occurred before, during, and after teaching.

The Practical Model of Planning and Micro-Instructional Systems Design Models

Based upon the detailed description of Sarah's preactive, interactive, and reflective thinking, a practical model of how an experienced science teacher planned her instruction (see Figure 4) was developed.

----------Insert Figure 4 about here----------

Although the model presented here is specific to Sarah and her cognitive style, it gives us an opportunity to compare it to the rational and technical design models to see how the two relate.

Instructional Systems Design Models: Instructional systems design draws its principles and models from a variety of disciplines: behavioral learning theory, cybernetics, information processing, cognitive theory, systems theory, media/design production, and several other fields. Models of instructional design are important in teacher education because they define goals and prescribe necessary activities for effective instruction. Instructional designers have developed a number of models during years of designing instructional practice. These models come from industry, education, the military, and a variety of other sources. Some of these models (see Andrews & Goodson, 1991 for a comprehensive review) are called micro-design models or "conventional models." The general purpose of these types of models is to: (a) specify and formulate instructional objectives, (b) develop assessment criteria relevant to objectives, and (c) design and develop instructional systems and provide arrangements and materials that enable the learner to perform as specified. Complementary to the conventional

(micro) instructional design models are macro-design or systems models that have different purposes, different systemic characteristics, and use different design approaches[5] .

Since the macro-design models and the systems orientation for solving instructional problems are used for complex systems of education, micro-design models, which are presented as classroom instructional models in literature and are used in teacher education programs, are selected to be compared with the teacher's model in this study.

Classroom instructional systems design models are all characterized by three key features: (1) a linear planning process, (2) an objective first approach to planning, and (3) a generic model for planning instruction. These models usually begin with planning instruction (specifying instructional goals, developing a list of specific objectives, developing test items for each objective, developing instructional strategies, and choosing instructional media and materials). After planning the instruction, the next step is to implement the plan, which in turn is followed by an evaluation of the plan to examine its effectiveness. The last and the most important step in these models is to review the instruction based on the performance information and to revise it as required.

The comparison between the above micro-instructional systems design models, with the theoretical model of Sarah's thinking, planning, and teaching suggests fundamental differences between the two (Table 3 summarizes these differences).

----------Insert Table 3 about here----------

The main differences are (1) a separation of instructional planning from implementation and evaluation by instructional systems design models while these phases are meshed in the teacher's model of thinking and teaching; (2) the linear or procedural model of teaching and planning in instructional systems design models as opposed to the teacher's cyclical model of

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[5] The characteristics of macro-design models contrast sharply with those of micro-design. Banathy describes these differences as follows:

> Macro-design is : (a) purposeful (teleological) in inquiry, action, and evaluation; (b) open to changes in the environment as well as to changes in the systems that comprise the systems complex of education; (c) continuous and dynamic; (d) participative and interactive with all those involved; (e) internally controlled; and (f) intrinsic as to implied concept of motivation (p. 110).

thinking and teaching; and (3) the concept of reflection or evaluation of effectiveness of instruction after implementation in instructional systems design models as opposed to continuous reflection in action or the cyclical process of planning, acting, reflecting, and evaluating in the teacher's model.

Despite the above fundamental differences between the two models, some similarities were also identified. First, the components of both models were almost identical. For example, students' background and characteristics, curriculum resources or textbooks, goals and objectives, results of analysis of previous instruction and recommendations for changes played important roles. Second, assessment of learning outcomes or testing procedures results in appropriate changes in future designs for instruction. Finally, prediction or pre-planning and consistency between goals or objectives, instruction, and assessment affect teacher's actions and reflections and students learning outcomes.

Discussion, Implications, and Recommendations for Future Research

The present study links a teacher's practice with instructional design models and procedures and examines the possibility that instructional design models can benefit from observing teaching practices in a natural setting. Thus, the results of the study have implications for instructional design models and principles as well as for teacher education and teacher cognition.

The results point to fundamental differences between the teacher's model of thinking and teaching and those of instructional design. These findings shed some light on the discussion of compatibility of the instructional design models and an experienced teacher's ways of thinking and teaching. As the study shows, the teacher has an operational methodology constructed during years of experience which works well in complex and variable classroom situations. Derived from practice, this is the most important influence on the teacher's actions. This result is supported by studies on teachers' thinking (see Calderhead 1987 for comprehensive review) and studies on teachers' implicit theories (e.g., Elbaz, 1981; Tabachnick & Zeichner, 1986). In these studies, the teachers' practical theories were referred

to a body of specialized knowledge that is acquired through training and experienced. Thus, ignoring the teachers' practical knowledge or trying to change it without taking into consideration the complexity and uncertainty of the classroom situation will not bring about the changes that instructional designers are hoping for.

Although the present study has explored a model of thinking and teaching that is different from those suggested by instructional design theories and principles, it is important to point out that the proposed practical model is a descriptive model that is specific to the teacher who participated in this study and should not be considered as a validated model for all teachers. More descriptive research on practical models of teaching is required to develop a model that best describes what teachers do. The results of this study suggest that it is time for instructional designers to question the effectiveness of their models and principles for school teachers and discrepancies between their conceptualization of the nature of teaching practice and the realities of classroom teaching.

The findings of the study also contradict the notion that the teacher is the implementer of specified curricular materials. The teacher in the present study adjusts the curriculum to fit her own beliefs and values, the students' needs and interests, and school context. The context of teaching influences the teacher's thinking and her course of actions. This finding also suggests that the image of the teacher as a manager of instructional materials that are carefully designed by instructional designers is too narrowly defined. Thus the role of the instructional designer as a developer of instructional curriculum for teachers or designer of instruction behind the classroom scene is also questioned.

The findings of the study, however, confirm the importance of reflection-on-action or evaluation of instruction in the practice of teaching and professional development of the teacher. Despite some differences, instructional design models are in accord with the teacher in emphasizing the continuous assessment of student learning outcomes. However, although the study shows that reflection is taking place in the midst of action (Freiberg & Waxman, 1990; Noordhoff & Kleinfeld, 1990; Ross, 1990; Schon, 1987; Wildman et al., 1990) as well as

subsequent to action, the notion of reflection-in-action is not acknowledged in current instructional design principles. The teacher's reflection-in-action, which brings together her preactive, interactive, and postactive teaching and makes her teaching responsive to the context, shows that the concept of evaluation, as the last step of teaching and thinking, should take new meaning and become an integrated part of the instruction. Constant dialogue with the student and updating information about the student's progress, attitude, expectations will integrate instructional decision making with the evaluation.

The present study, along with other recent studies on teacher's reflective thinking, suggests that instructional designers should pay more attention to their conceptualization of evaluation of instruction and re-examine their procedural models in this respect. Further study is also required in the area of reflective teaching to identify the nature and the content of reflective thinking and its effect on teachers' practices.

The findings also show that the teacher's beliefs and images of herself, which are associated with her biography, experiences in the classroom, her relationships with other teachers and school authority figures, and recollections of being a student in the classroom, influence the way she designs, acts, reflects, and evaluates her instruction. This is consistent with the findings of previous ethnographic case study of an experienced middle school language arts teacher conduct by Moallem, Driscoll, Papegiannis and Struzulla (in submission). The same result is also supported by the narrative studies conducted by Connely and Clandinin (1990), Cohen (1991), and Louden (1991). These researchers reported that classroom teaching practices were rooted in personality and prior experience. These findings suggest that if instructional design theories and principles or instructional materials are to be adopted by teachers, special consideration should be given to the beliefs of teachers about their role in the instructional process. Interested in changing teachers' perspectives on their work, the study suggests that educators in the field of instructional systems design take into consideration evidence that learning to teach is not a two-step process of (1) learning theory and (2) putting theory into practice. Teachers' prior knowledge and beliefs about teaching are

powerful and important elements with which instructional designers must contend. Until educators in the field of instructional design develop ways to invite teachers to share their lay beliefs, comprehension of the implications of those beliefs, and ways to encourage and sustain critical conversations about those beliefs, they will not be successfully practicing with teachers the very principles that they are teaching them to employ.

The link between two closely related fields of research, teacher cognition and instructional design theories and principles suggests that instructional designers take into consideration the findings of the research in teacher cognition to evaluate effectiveness of theories and models in school systems. The integration of research within these fields can bring about the appropriate changes in both fields of the study.

The study shows that preactive, interactive, and reflective thinking are not conceptually separated in the teacher's thought process (see Borko & Shavelson, 1990 for similar result). They are interrelated components of a broad process of thinking about teaching and should be addressed simultaneously in the future study of teacher cognition . Only a holistic approach to the study of teacher cognition can give a complete picture of why teachers do what they do.

The interactive relationship between the teacher's biography, knowledge and beliefs, and theories of actions and her preactive, interactive and reflective thinking reveals the extent to which teaching is a social act. It suggests that, in order to understand teachers, it is necessary to understand their social and cultural contexts of teaching, and that in order to understand present teaching practice, past experience should be explored. These findings indicate that teacher education programs should provide students with opportunities to see the context specificity of the teaching and learning process to begin to think like teachers. They should help students of teaching understand that it is impossible to know anything in general about teaching without knowing something in particular, thus revealing the inherent complexity of the teaching and learning process. This finding also has implications for teacher education research in teacher change processes and suggests that contexts and constraints should be examined in relationship to teachers' present actions.

Finally, the present study shows the importance of assessment as a means of self-evaluation for both students and the teacher in teaching and learning process. This result suggests that teachers should receive assistance in examining their assessment practices. If meaningful learning and higher order thinking are educators' goals, then assessments that are consistent with these goals must be encouraged. Training teachers to be reflective about their own actions and assisting them to develop assessment practices which are consistent with their goals for meaningful learning should be more seriously considered by teacher educators.

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Table 1: An Example of Sarah's Daily Plan

Week	Day	Content
First week	Aug. 27	Film: "Scientific Method" 4842 (23) Excellent Show early Textbook: Merrill: p. 2-7 Q 3-10 p. 6 p. 8-10 Q 1-4 p. 10 Scientific method 1) Observation 4) Theory 2) Hypothesis 5) Law 3) Conclusion 6) Model 7) Scientific method

Table 2: Examples of Sarah's Processes of Reflection-in-Action

Unexpected Event/Problem	Source of Information	Reframing the Event/Problem	Experimentation/ Action	Decision	Reflection-on Action
• Students are off task. They are socializing instead of working.	*Observation:* Students' responses *Memory:* These are studious students, they should not be off task.	Students are not motivated. They must be bored or they think the task is easy.	Change plan, offer reasons for the task, offer consequences of the task.	Strategy is not working; try another alternative. Keep asking questions Help them identify the needs.	Bookwork is boring. Change the activity or come up with another strategy.
• Students in other class asked a lot of questions about the concept, but no one asks question in this class.	*Observation:* Students' responses *Memory:* Both class are at the same level. Something is wrong.	They may not understand the concept but are afraid to ask questions.	Encourage them to to ask questions. Ask them some questions to make sure they understood the concept.	The problem cannot be tested now.	Prepare a quiz.
• Students misinterpreted teacher's example.	*Observation:* Student's question.	Students' interpreted from her example that she favors girls.	Give explanation. Clarify the example.	Working well, so continue.	Be careful for the next example.
• Students have not finished the test, but the time for the activity is over.	*Observation:* Students' response.	Test is too long for the time given.	Reassure students about the test results, cannot give more time but consider the problem.	Does not seem to work/No alternative available.	Shorten the test.

Table 3. Comparison between Teacher's Model and Instructional Design Models

Teacher	ISD
-Importance of context knowledge	-Emphasis on decontextualized knowledge and skills/research based knowledge and prescription
Behavioral objective is one of the factors influence decision making decision	-Behavioral objectives as a main and starting point for planning and making
-Importance of subject matter and teacher's cognitive style on planning	-A generic planning model for all subject matters and different situation
-No separation between design, development, implementation, and evaluationim	-Separation between design, implementation, and evaluation
-Cyclical and interactive	-Linear and procedural
-Reflection is an important component of thinking during action	-Evaluation (reflection-on-action) is an important component of planning
-Reflection is present in every phase of thinking and teaching	-Evaluation is after implementation of instruction and focuses on past experience
-Reflection happens both in the midst of action and after action	-Evaluation is an end step of instruction
-Reflection is not limited to educational consequences	-Evaluation should be focused on learning outcomes

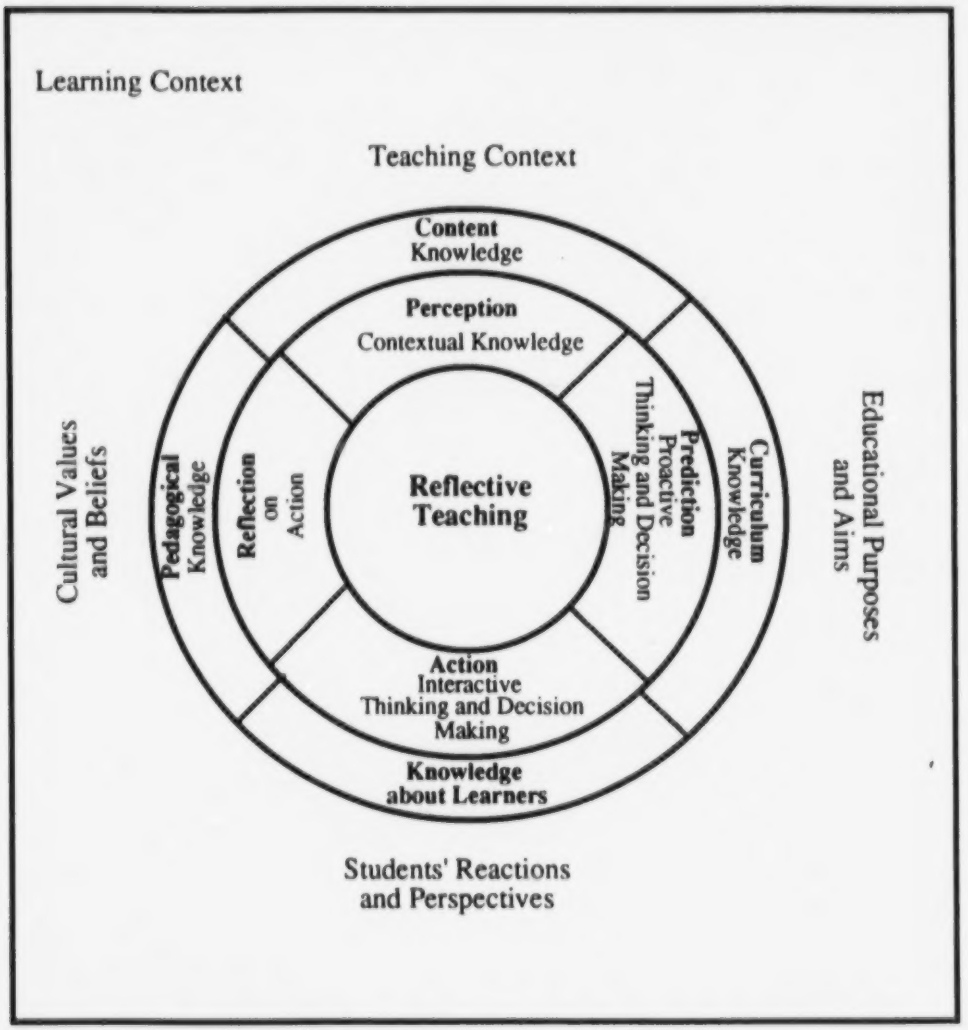

Figure 1. Conceptual Framework for Research on Teaching

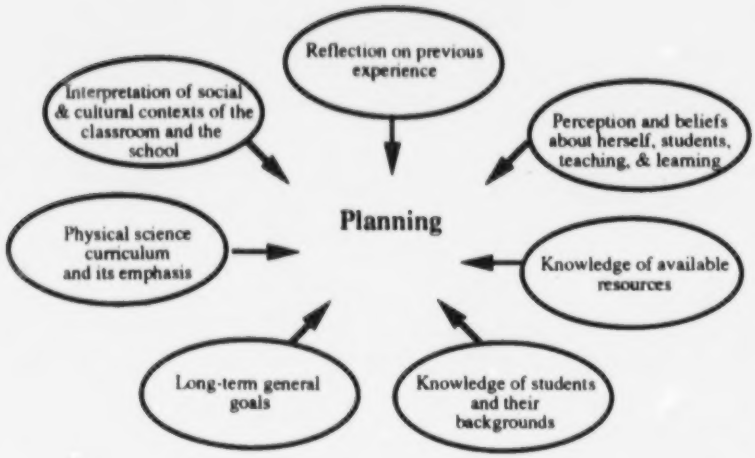
Reflection on previous experience
Interpretation of social & cultural contexts of the classroom and the school
Perception and beliefs about herself, students, teaching, & learning
Planning
Physical science curriculum and its emphasis
Knowledge of available resources
Long-term general goals
Knowledge of students and their backgrounds

Figure 2. Factors Considered by Sarah during Planning

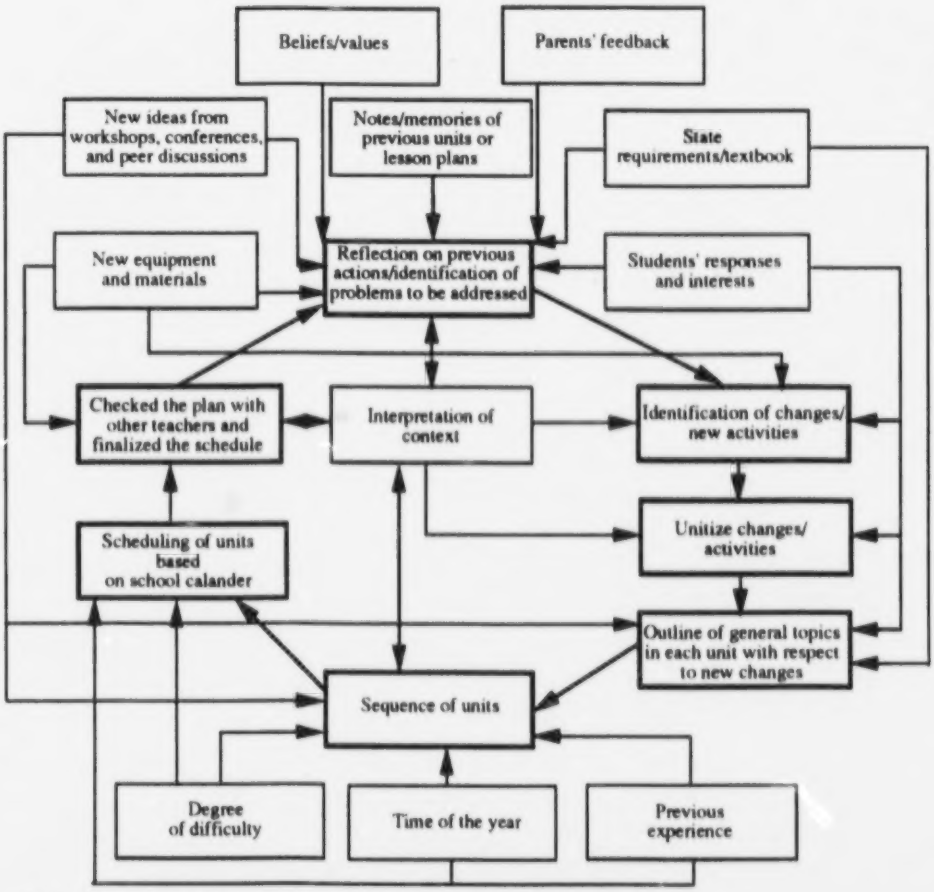
Beliefs/values
Parents' feedback
New ideas from workshops, conferences, and peer discussions
Notes/memories of previous units or lesson plans
State requirements/textbook
New equipment and materials
Reflection on previous actions/identification of problems to be addressed
Students' responses and interests
Checked the plan with other teachers and finalized the schedule
Interpretation of context
Identification of changes/ new activities
Unitize changes/ activities
Scheduling of units based on school calander
Outline of general topics in each unit with respect to new changes
Sequence of units
Degree of difficulty
Time of the year
Previous experience

Figure 3. The Elements and Process of Sarah's Yearly Planning

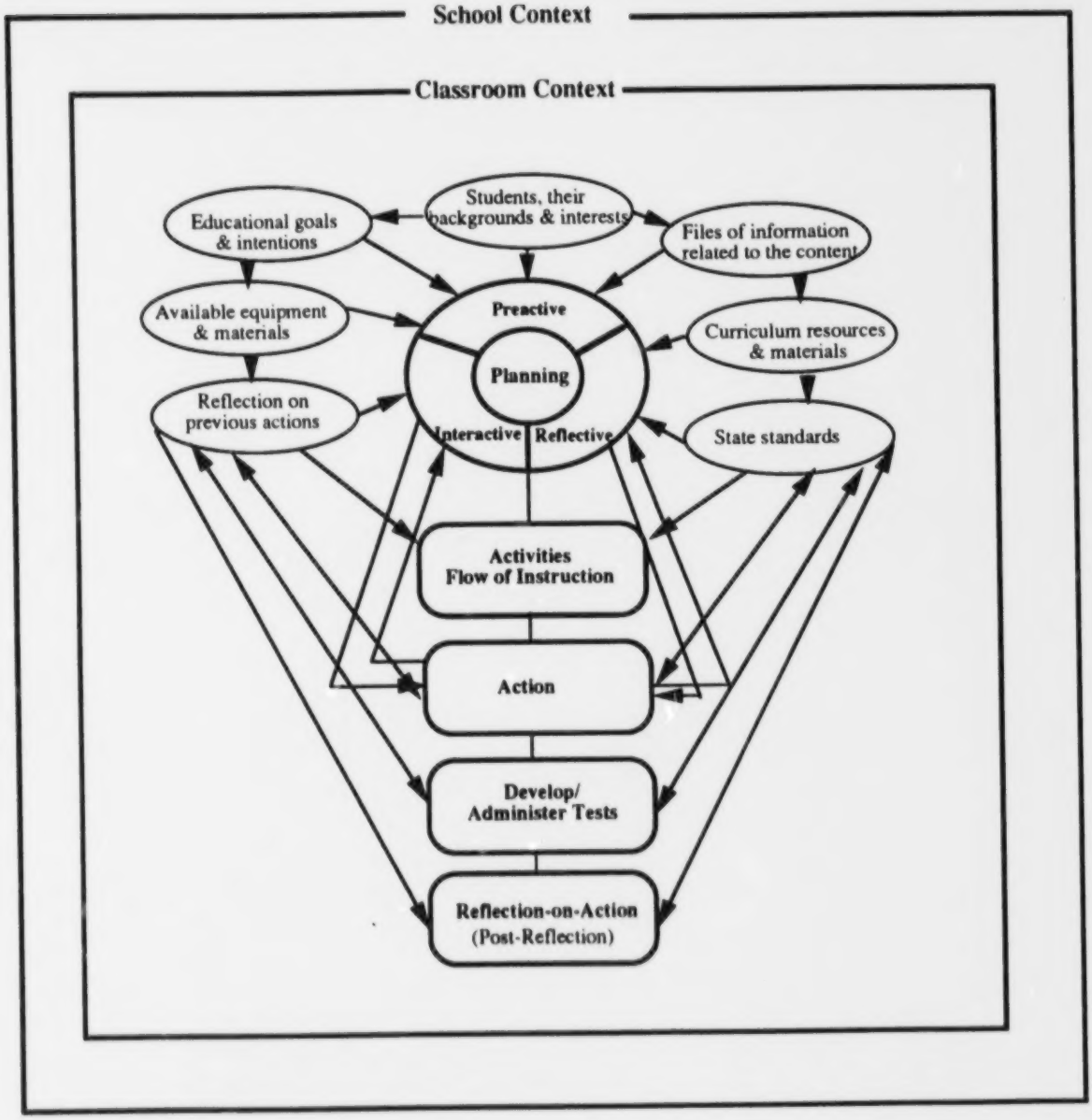

Figure 4: Practical Model of Planning